Title: Deliverable 1.1 “Literature Review and Initial Modelling”

Synopsis: This report presents the current approaches and trials, as well as modelling aspects of OLTC-enabled LV transformers.

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Executive Summary

This report corresponds to Deliverable 1.1 “Literature review and initial modelling” part of the Work Package 1 “On-load tap changing LV transformers” of the project “Active Management of LV Networks” jointly funded by EDF and EPSRC.

The Active Management of LV Networks project has been established in order to investigate the effect of applying active management techniques to increase the ability of low voltage networks to accommodate higher number of low carbon technologies, in particular photovoltaic (PV) systems and electric vehicles (EV). The project will focus on the utilisation of on-load tap changing transformers and coordinated control of low carbon technologies themselves and other technologies to control voltages and congestion in the network.

This document presents the initial modelling aspects of LV networks, including the on-load tap changer (OLTC), as well as load and PV profiles. In addition, a control logic for the OLTC is proposed and its performance assessed considering different PV penetrations and also different monitoring approaches. These models provide a solid foundation for the LV network simulations to be carried out throughout the project as well as the further development of control logic. Some parameters which are UK specific will be adjusted to the French standards when appropriate.

A summary of the main aspects of this report is presented below.

- **LV Network Modelling.** A real-life UK LV network from the North West of England has been adequately modelled considering its three-phase nature and single-phase customer connections. The distribution system analysis software OpenDSS has been used for this purpose.

- **Load Modelling.** The CREST tool, developed by Loughborough University, is used for modelling the domestic load profiles given its high granularity (one minute). The load of each individual household is modelled realistically considering type of day, seasonality, occupancy and the associated use of electrical appliances.

- **PV Modelling.** The CREST tool is also used for modelling the PV generation which takes into account the correlation between the domestic lighting demand and PV generation. These models are then allocated to specific locations and sizes of PV installations.

- **Transformer and OLTC Modelling.** The transformer considers the real transformation ratio (11kV/433V). OpenDSS provides the internal control response of the OLTC considering +/- 8%, 2% per tap (considered to be available from manufacturers). The main input for the OLTC is the voltage target at the busbar that is set by the control logic due to voltage issues or adopted as 415V during normal circumstances.

- **Voltage Control with Remote Monitoring.** A control logic is proposed aiming at regulating voltages at the remote ends of LV feeders considering monitoring at end points. When applied to the real-life LV network considering different PV penetration levels (30 and 50% in terms of number of houses with PV panels and same distribution for all feeders) during a typical UK July weekday, the logic succeeded in maintaining the voltages at all customer connection points within the UK statutory limits (+10/-6% of nominal, considering the EN50160 standard).

- **Voltage Control without Remote Monitoring.** A voltage estimation method is proposed in order to substitute the need for remote monitoring of end points. This method calculates the voltage drop (or rise) at the end of the feeder by considering the busbar voltage and assumptions regarding the typical nature of UK residential LV feeders. The control logic was adapted to consider the estimated voltages and applied to the real-life LV network (similarly to the case with remote monitoring). Initial results show that the use of estimated voltages can be as effective as that when using monitoring.
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